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ABSTRACT

In evaluating IMAGE, an open-ended computer assisted learning program designed to enable English children to produce, modify, and print artwork created on the computer, teachers' perceptions of the program were focused on what the software package can do and what can be learned from using the program. Eighty teachers utilized the package in their schools and colleges. Overall the verdict on IMAGE was favorable. The report showed that IMAGE was usable in many situations, over a wide range of environments, and by teachers with very different educational philosophies. Non-specialist teachers as well as specialist art teachers with a variety of interests and approaches to art viewed the package as valuable. The teachers' evaluations raised further questions about art education and computers that extended beyond the role of the IMAGE software package. (CK)

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What can be Learned from IMAGE? Teachers' perceptions of the educational value of an art package

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WHAT CAN BE LEARNED FROM IMAGE? TEACHERS' PERCEPTIONS OF THE EDUCATIONAL VALUE OF AN ART PACKAGE

Introduction

In evaluating a software package teachers need to consider four main questions:

> What can the software package do?
> What can be learned from its use?
> Can this learning be achieved better by other means?
> Can the package be introduced successfully into the school or classroom and if so, how?

This paper is concerned with the first two of these questions and with a major aspect of the third. It analyses some teachers' views on ways in which an art package called IMAGE might be used in schools, given favourable circumstances. A later paper will deal with the fourth question, analysing the various kinds of organizational or practical obstacles that teachers met when they attempted to introduce and use the package.

What can IMAGE do?

IMAGE is an open-ended CAL program designed to enable children to produce, modify, story and print out artwork created on the computer. It is, so to speak, the equivalent in terms of images of the wordprocessor. The arrival of suitable wordprocessor packages in schools has brought the computer into the language curriculum; art packages such as IMAGE promise to do the same for art.

The main elements in the package are the program itself and a 72-page manual. The latter provides instructions on the use of the program's painting facilities, ways of storing pictures produced and methods of configuring the program for use with different combinations of input and output devices. Several pages of ideas and tips are also provided on ways of using the package, together with a short bibliography made up of books on art and design, computers and both combined. The program enables the user to colour each pixel in a 140 by 232 window on the monitor screen using any one of eight colours. This sets the upward limit of definition, colour and tonal range for the images produced. In practice the task of colouring individual pixels is so time-consuming and difficult that IMAGE, like every other graphics package, provides a set of second level methods of speeding up the process. The methods chosen unavoidably create pressures to use the medium in one way rather than another; which in turn affects what can be learned from using a particular package. At this second level the IMAGE user can

replicate the fundamental actions involved in using most two-dimensional art media, namely the creation of line and shape in a range of colours. A mixing room facility is provided that enables the user to set up a pattern of pixels using different basic colours. Where the tones of the colours chosen are similar this gives the impression of a new intermediate colour, where the tones are very different the result is a textured effect within which the colour elements remain separate at normal viewing distances. Curved or straight lines of varying length and width can be drawn together with dots of different sizes. A simple 'air spray' device is also provided. Shapes are drawn essentially by outlining a closed figure and then filling it with the chosen colour or pattern. The figure can be drawn free-hand or by using one of the procedures for making up common geometric shapes such as circles, arcs and triangles in whatever size is needed. Any rectangular part of the screen image can be rotated, reversed, altered in size vertically and/or horizontally and repeated on another part of the screen.

Any colour in the picture can be changed to any other, and all or some of the colours used can be rotated through the palette available. There is also provision for showing the effects of combining different colours of light using the main logical operators (and, or etc). The possibility of creating intermediate colours can also be used to create a pattern which can then be spread over any part of the screen as required. Finally there is a very basic text creation facility. Letters produced using it can then be manipulated and modified in the same way as any other shapes.

What can be learned from using IMAGE?

As part of the developmental testing of the package the Project team responsible for creating IMAGE invited some 80 teachers to take part in a DES sponsored course built around an advanced prototype version of the program. This involved an initial meeting to introduce the package, a period in which the teachers tried out the package in their schools or colleges, and a final meeting in which teachers and outside speakers reported their views on the package. The teachers each provided an evaluation from which the Project team chose 19 for inclusion in a report (1) that was circulated as a discussion document for other teachers. This comprised some 20-25,000 words of unedited text, and some 60 pages of illustrations.

Clearly the report is not usable as statistical evidence for what teachers generally might see as the role of IMAGE in their own classrooms. The teachers on the course were probably untypical, while the 19 evaluations included were chosen specifically to cover the range of views and ideas expressed, not to provide a statistically representative sample of them (2). Furthermore the nature of the evaluations provided varied. Some

included illustrations, some worksheets or children's own evaluations of the program. Some based their reports on close observations of specific groups of children, others discussed the package in more general terms. Others again considered the notion of art packages in general, evaluating them in terms of their own philosophies of art and art education.

However this very diversity and lack of regimentation makes the collection an excellent first source for mapping out the range (as distinct from the frequency) of perceived uses for IMAGE. While not all such uses will necessarily be present, many of them will, and the presence in even one report of a perceived aim is prima facie evidence for its possible existence more generally. For the same reasons it is also a useful initial source for evidence about areas of disagreement between teachers about possible uses for the package. Given the assumption that teachers have a shared professional language for discussing such issues we can use the evaluations as data to construct the outlines of a provisional analysis of the underlying issues, cast in the language of teachers rather than that of either information technologists or curriculum theorists.

To do this the report was checked for all occurrences of stated or implied aims or educationally relevant outcomes, regardless of whether the teacher was indicating that IMAGE was suitable or unsuitable for achieving it. The teachers used a very wide range of terms but these fell into three broad categories, each in turn subdivisible into several more. Both these divisions and the allocation of items to them are debatable at a detailed level (although directly checkable against the published report). However the categories do bring out some important problems clearly.

The first major category was that of non-art related aims. This included various general educational aims, aims relating to other curriculum areas and several kinds of indirect outcomes that the teachers reported as following from, or likely to follow from, the use of the package. Two major art related aims categories could also be distinguished. One set were cast in terms of specific elements of the activity of artistic creation (e.g. craft skills, the object to be produced, or the perceptual sensitivity to be improved). The other approach was to discuss the package in relation to a particular kind of artistic activity or discipline as a whole, such as fabric design, or collage.

Aims from these three categories occurred in different proportions in each evaluation, while the specific aims that were mentioned by teachers even within each category were also highly variable. The various categories and their subdivisions are shown in Table 1, with disputed categories indicated.

TABLE 1 Teachers perceptions of aims and outcomes of using IMAGE.

*Categories marked * contain at least one negative evaluation.*

Non-art aims

* motivational and attitudinal outcomes
developing problem-solving skills
practising co-operative group work
learning in non-art curriculum area
* promoting desirable indirect effects on teachers learners and curriculum

Element aims

visual awareness of:
line
colour
shape
* appreciation
* learning craft skills
* conceiving the subject of work of art
knowing qualities of material used
creation or embellishment of art object

Discipline/activities aims

Mastering a fine art activity or discipline, e.g.:

drawing
painting
printing
photography
use of video camera
animation
screenprints
aquatints
collage

Mastering a design activity or discipline, e.g.:

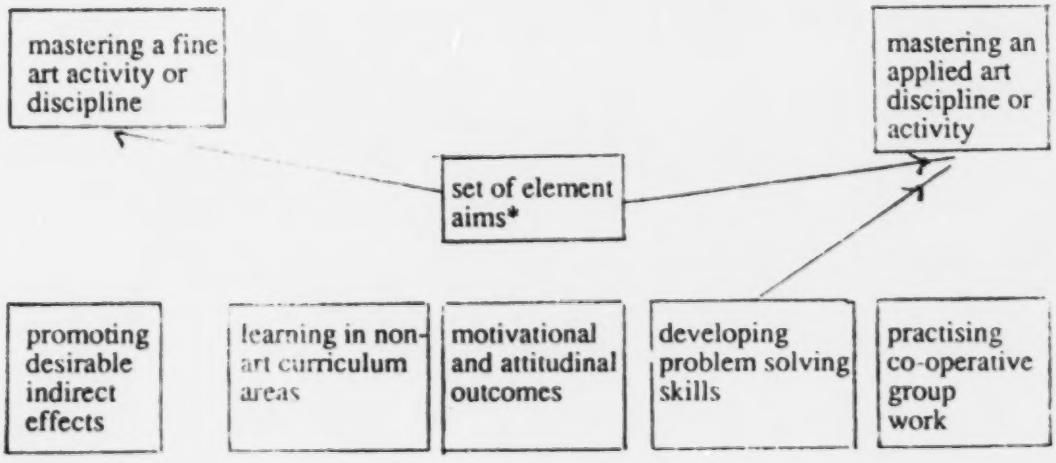
design for knitting
embroidery design
weaving design
fabric design
canvaswork design
textile design
wallpaper design
designing lino cuts
design for wood engraving

These categories and their interrelationships are naturally to some extent speculative, however such speculation is worth attempting because it provides a basis for generating further hypotheses and a simplified picture of the data that others can revise critically. Two kinds of relationship between the aims need to be considered. In some cases there appear to be conceptual relationships between the aims categories. The claim here is that anyone pursuing a particular aim is necessarily also concerned with others that stand in certain semantic relationships to it. Diagrams 2 and 3 show what I consider to be these relationships, at two levels of detail.

Diagram 2 Postulated conceptual relationships between main aims categories

A - B: Concern for aim A implies concern for aim B

* : For internal relationships within this set of aims, see Diagram 3.


mastering a fine art activity or discipline
mastering an applied art discipline or activity
set of element aims*
promoting desirable indirect effects
learning in non-art curriculum areas
motivational and attitudinal outcomes
developing problem solving skills
practising co-operative group work

A concern for the mastery of either fine or applied art, in any of their specific forms, requires an interest in aims covering all of the aspects of artistic production listed under the elements category. Any design discipline, whether it be fabric printing, photography or weaving, for example, will require the learner to develop capacities of appreciation, relevant craft skills, an ability to produce certain kinds of physical objects and so forth. What defines the difference between the various disciplines here is not that these elements are not all present, but rather the particular form in which each occurs within that discipline. In that sense aims described in terms of the elements are equivalent to those presented in discipline terms. However a discipline defined specification constrains what kinds of art activities are to follow, whereas the element descriptions do not. This is not to say that the teacher or learner using element defined aims is not obliged to make real choices of actual craft skills, or of definite subjects for the work of art, and so forth. But what they are not required to do is make these choices from within subsets predetermined by the choice of a given discipline. Thus a teacher using element defined aims can be highly eclectic in her approach, while still remaining true to her intentions. The teacher who sets out, by contrast, to help learners master a given discipline or art form is automatically far more constrained.

While the art related categories can be linked together as wholes, this is not so for the non-art category. Only one subcategory (namely a concern with problem-solving) seems to have any semantic connection with the art categories, and there only with that of applied art. Although more or less any educational activity involves solving problems, problem-solving is related to the applied arts in a much more definite way because of the presence of functional criteria as well as aesthetic ones for success.

While the semantic links in Diagram 2 look rather scanty this is important in itself; for the implication is that most of the non-art aims are conceptually independent both of the art specific aims and of each other. This is not the case within the set of elements subcategories though, as Diagram 3 indicates. Firstly, a desire to develop visual awareness involves a concern for the three more basic elements of line, colour and shape. Similarly an interest in developing the learner's capacity for artistic appreciation requires the growth of appropriate visual awareness, an understanding of the properties of the material used and of the subject of the work being judged. Arguably it also demands some knowledge of, if not actual competence in, the craft skills required to create the work involved. It might also be argued that craft skills are needed to develop an adequate visual awareness.

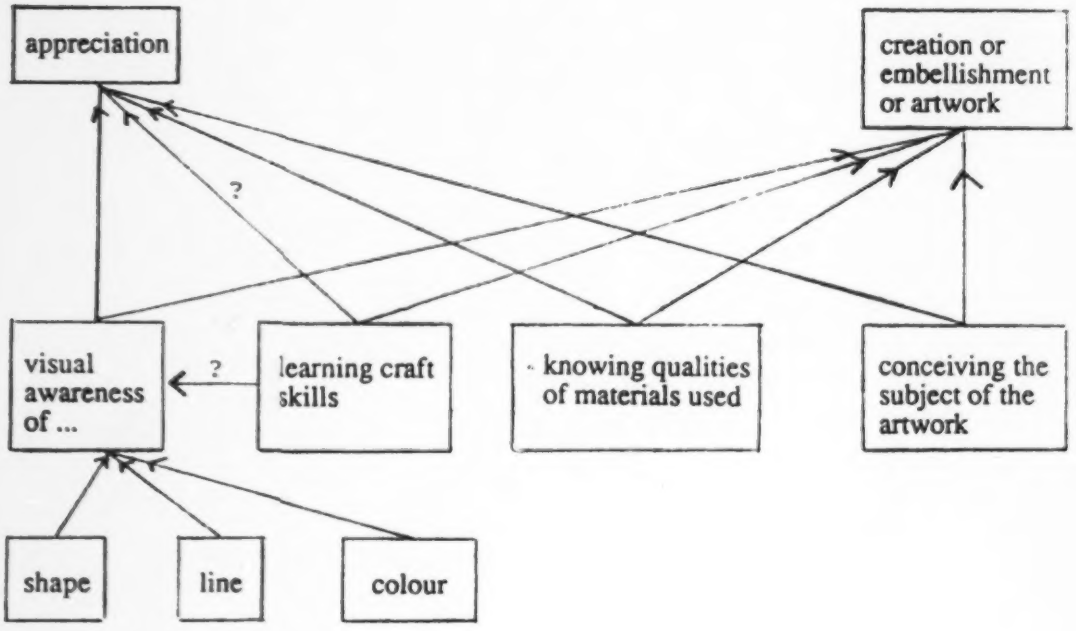
A comparable set of conceptual links exist when it is the creation of an art object rather than its appreciation that is the central aim. Here, too, success implies reaching a certain

level in visual awareness, a sufficiently detailed conception of the subject and so on. Neither appreciation or creation of art is reducible to these simpler achievements, but both require that they be individually mastered and collectively integrated within the activity of appreciation or the production of the work itself.

Diagram 3 Hypothesized conceptual relationships within the set of element aims

A - B: Concern for aim B implies concern for aim A

A ? B: Possible conceptual relationship



Causal relationships between aims are also important. These are empirical and contingent rather than necessary. For instance, successful acquisition of problem-solving skills does not logically require a commitment to co-operative group work on the part of learners or teacher. However it is likely that attempting such co-operation will in fact make learning problem-solving methods more likely. Similarly, if we consider motivational aims such as increasing a learner's self-confidence and enthusiasm, these are not logical preconditions of his learning, say, weaving more easily, but in many cases they will in practice be essential if such purely artistic aims are to be achieved. The nature of causal relationships in this whole area is very complex, and I am not competent to even attempt to summarize them. Clearly in identifying these the everyday experience of teachers, systematic classroom research and laboratory based studies in such areas as perception, cognition and social psychology, are all relevant. So too would be the creation of explicit models of teacher and learner conceptions of the nature of art and a education. Ideally all this would the need to be linked to an equally formidable array of research on the role of computers in teaching and learning.

Is IMAGE better than conventional media?

One way of evaluating IMAGE is to compare it with conventional art media such as pencil, pen, water colour, pastels and oils. Five features pick out much of its distinctive character as revealed, implicitly or explicitly, in the Report. IMAGE differs from all or most of the conventional media in these ways:

The computer connection IMAGE involves the use of computers while the other media do not.

Its role in achieving non-art specific aims It can be used more easily to achieve some of these aims.

Crudity Line, colour and shape can all be handled with more subtlety through conventional media.

Flexibility IMAGE is more flexible; effects can be changed or reversed more easily than in the conventional media.

Ease of use The user's physical dexterity affects the quality of work produced far less when IMAGE is used rather than a conventional medium.

Some teachers' reactions to IMAGE appeared to be influenced (either positively or negatively) by the mere fact that a computer would be involved in the creative process at all.

> (Image) belongs to the world of computing, a world that is having a considerable influence on the quality of our lives and the way we lead them. In much the same way that we can use art to help understand the world about us so we can use computer art at least to help us understand the world of computing. (3)

> On the one hand I feel I am right to reject this intrusion of the micro and yet on the other I find myself feeling ashamed at wishing to withold this new wonder from my pupils. Will they thank me either way? Am I really a Luddite? ... It is my experience that most lay people see the computer as being a plaything, a machine of fun, a pocket Walt Disney! ... The big question has always to be 'Why do I need one?' as well as 'How can I use one?'. If you don't ask both questions then you simply fall into the trap of following trends. How many hoola hoops, pogo sticks, skateboards etc. are still in use? (4)

Supporters of the linkage between art and computers saw gains in status and respect for the art teacher and/or her subject, together with opportunities for integration with other parts of the curriculum. Many objections mentioned centred on technical limitations discussed below. However there might also be many teachers who would object to introducing computers simply because they saw them as dehumanizing or threatening objects. For obvious reasons such teachers would be unlikely to have become involved in the Project.

For some teachers the important aims included those which had nothing specifically to do with art at all. Like other open-ended computer packages IMAGE automatically offers opportunities for exploration and experimentation, with immediate feedback on the effects, while for most children using the package was an interesting and exciting experience. Primary teachers especially welcomed the opportunities this provided for exploration of the possible effects and for co-operation in planning and building up pictures. It also allowed cross-curricular work of various kinds.

> Discussion periods with the whole class and the computer enabled the children to share their discoveries, ask questions and demonstrate their expertise. It became a great medium for problem-solving, exploration, prediction and general discussion. For this reason, its contribution to

> children's language acquisition and communication skills has been considerable. (5)
>
> IMAGE lends itself to other areas of the curriculum. It naturally forms part of the language work achieved in school, as children discuss their ideas with each other. The implementation of TEXT will extend language work, to allow children to present words in various shapes and colours on the screen.
>
> In science it is a useful addition to the teaching of colour in terms of light and colour mixing.
>
> In mathematics it may be used in conjunction with the Floor Turtle, where movements and designs may be copied from screen onto the floor or vice versa. Also it may be used in the understanding of shape, or scale factor, or rotation. (6)

For most teachers however the place of IMAGE in art education was naturally given greatest importance. The package was used to create artwork in three quite distinct ways. One method was to produce the piece using only the computer. Here the monitor image or the printout from a monochrome or colour printer was itself the final work of art, although the differences between the two were not overlooked.

> Image begs the question 'Where is the art?', and further 'Who is the artist?'. Is the art work that which appears on the screen, is recorded on the scrap-book disk, is hidden in the program or is it the printout? Could the artist be the machine operator, the machine or the programmer? (7)

The second strategy was to use the package to produce an output (such as a printout on paper or transparent film) that was then embellished or incorporated in some way to produce the final work, for instance as part of a collage or as a hand-coloured version of the original printout.

> ... there is unexplored potential in students actually making drawings and collages from printouts. For example, a project might be to create a repertoire of monochrome textures which could be used in screenprints or even aquatints ... I would like to try coloured acetate, or take images down to the Xerox department and print them on coloured acetates. We could then run an overhead projector with collaged images as a 'Light Show'. This could be coupled with sound and lights as well as transparencies photographed from collaged designs. (8)

Finally some teachers, especially those interested in applied art, used the package purely as a kind of sketchpad for planning purposes, the actual artwork being produced subsequently entirely in the conventional way. When used in this planning mode the speed and the relative ease with which most effects could be changed was considered a valuable asset.

> 'A' level students found ... advantages when working on designs for wood engraving, where texture and pattern play such an important part. Hitherto designs had been worked out on scraperboard and with ink, before transfer to the wood block. The whole process of preparation of designs was speeded up without any loss of craftmanship or intuitive use of the wood, as the marks forming patterns on the computer that had still to be interpreted and could not be imitated when cutting the wood. A whole new vocabulary of marks and patterns was made possible with the package.
>
> CEE students now beginning linocuts are finding similar advantages. There is obviously great scope within the package for designing screen prints which as yet we have not explored. (9)
>
> One fourth year girl had been given half an hour per week on the computer using Image during my free period. She liked the program very much, in particular the colour series which allowed her to first create a pattern/design and then eliminate or change colours at her discretion. She thought it would be an excellent way of producing a geometric design and was able to consider the many combinations and colourways using the colour series before deciding on the best design which she could use for a suitable fabric print. (10)

Crudity of line and colour range limitations were very important for several teachers, although the distinctive quality of the colour produced on a good monitor was valued by others.

> The pencil has a greater range of tone, texture, line width and control in the human hand. So although the computer can be used to draw it will not replace the pencil. Equally it fails in the range of colours available compared to tempera or oil paints. There is also no texture on the surface of the paper after the image has been processed by the printer. In general it can be said that the computer will not replace any of the existing art materials. In that respect it is like an electronic version of

> the felt-tip pen which is still trying to find a satisfactory role for itself in the art room. (11)

The program's ease of use made it possible for children to achieve quite complex visual effects quickly and without needing the dexterity and delicacy of touch that other media demand. Some teachers saw this as a welcome release for children from the frustration of being able to envisage a result that they lacked the motor control to achieve. However to others this apparent benefit eliminated the essential element of skilled craftsmanship from art education.

> To me the various craft processes are very important (including) such activities as painting, drawing and printing. Computer graphics engage the mind, but not the hands. Where is the craftmanship? You may feel that I am overplaying the craft element of art education, but I would ask you to consider in how many other areas of the curriculum is there a strong emphasis on the development of manipulative skills ... why not (have both) craft-oriented lessons and Image-based lessons? Obviously Image was never intended to replace more traditional teaching materials entirely, if at all. However, time, as much as money, is in short supply for the Art/Craft teacher. The amount of time required to use computer graphics effectively would inevitably lead to the ousting of much valuable craft work. (12)

A related concern was the negative effects of ease of use upon the child's capacity to fully attend to the object being painted.

> Because the computer is full of stunning techniques, the danger is that the exciting image may become an end in itself for the artist and the programmer. It is very easy to be seduced by striking pieces of art work which are all technique and have no real content and surely the essence of art in schools is that the work should have both understanding of the object and the way it has been depicted. (13)

Overall the impression from the Report is of the package being used by teachers for widely different reasons and against a background of distinctively different conceptions of the nature of art, of art education and of computers. In these circumstances, divergences in their assessment of the package was only to be expected.

Discussion

If we think of the evaluations as essentially about deciding the relative merits of IMAGE and conventional media, then the list of features discussed above marks out the deeper structure of much of the debate within the Report. Many divergences in the teachers' reactions to IMAGE can be explained as reflecting either different priorities as between non-art and art aims, or between subtlety, ease of use and flexibility. Another source of debate is the desirability or otherwise of greater ease of use and/or encouraging any connection between art and computers.

How far the various perceptions the Project teachers had of the computer are compatible with each other is hard to judge. So too is the long term importance of this question. General attitudes to computers have changed significantly over the past few years, as they have appeared in more and more social and work contexts. It may well be that with greater familiarity teachers, children and parents will lose interest in the mere fact that computers are being used in schools and begin to look through the computer, so to speak, directly to the tasks for which it is used. If so, the indirect effects of computer use that some art teachers anticipated will become progressively less.

The value of art packages for promoting such general aims as co-operation and problem-solving looks more durable. The ease with which changes can be made and different versions of a picture saved are clearly helpful here. However if such aims can be pursued independently of the art aims, then it is quite possible for teachers to treat the package's connection with art as at best a source of motivation for some children, or at worst as an irrelevance. This may be picked up particularly in primary classrooms, where the package may be seen as contributing to an overall policy of co-operative discovery-based learning, rather than to art education as such. Similarly the package might be used for subject-specific work in areas such as mathematics or science without any reference to art at all. My own feeling is that the package is probably less likely to feature in these other curriculum areas than the designers may hope, at least in secondary schools. To set up and use a system of this kind a teacher would need to see considerable advantages in it. For mathematics there are more obviously relevant packages available, and its role in the science curriculum may be too small to justify the effort.

The core of its educational value lies in its use in art education, and here the debates over flexibility, crudity and ease of use form an interlocking set of issues. Whether or not the package is to be employed to create artwork directly clearly alters the relative importance of the package's characteristics of crudity, flexibility and the reduced role for craft skills.

When actually creating artwork the lack of subtlety of the medium is a real limitation. However this weakness becomes progressively less serious as we move from using the computer to create the whole piece to allowing embellishment, or to just employing it for the creation of quick sketches and tryouts. Having said that, even as a sketching medium the weaknesses remain; the package is not, for example, easily usable for tonal sketches. Conversely the capacity to change an effect quickly for another may make it easier for some children to envisage alternatives, and thus to appreciate better the relative merits of different arrangements.

This lack of subtlety compared with conventional media is partly to do with the input and output devices used, most of which cannot reproduce very fine lines or colours, but more fundamentally it is a function of the limited memory of the computers used. If we are concerned with developing appreciation the relative crudity of computer-based artwork limits the level of visual awareness (and hence appreciation) that learners can develop through its study and discussion.

The conceptual analysis of the aims again emphasizes the importance of limitations in colour and line resolution, for these affect virtually all the art related aims that teachers mentioned. However as more powerful machines such as the Amiga and the Archimedes become available for schools, memory-based constraints on what such packages can do will be steadily reduced. Whether at any point in the near future computers will be able to match conventional media is doubtful. Having colour palettes with thousands of colours is one thing; being able to include them all in the same picture is another. Improved resolution too will require advances in monitor construction to reduce prices to an acceptable level.

The issue of the role of craft skills is more complex. For the teacher interested in non-art aims only, ease of use is an unqualified benefit. Nor presumably would the lack of practice in craft skills concern art teachers using IMAGE only as a planning aid. Another constituency for the package is no doubt those teachers who see art in the context of media studies, linked to video or television technology perhaps. Where the issue of craft skills does bite is in the area of the fine arts as traditionally conceived. Even if one does not accept that craft skills are worth developing in their own right, the point made earlier about the possible role of craft skills in developing appreciation and visual awareness remains. If, for instance, the slowness of conventional methods of creation encourage closer attention to the piece and to the subject of the work in many children, this in turn may well increase visual awareness and appreciation. The basic question here is straightforward; what effects does the use of a package like IMAGE have upon children's capacities to create and appreciate conventionally created art? Certainly the assumption

that art packages can just be used alongside traditional media without any side effects strikes me as very implausible. What those effects would be, however, is a matter for investigation rather than speculation.

Overall the verdict on IMAGE must be a favourable one, albeit with important reservations. The report shows that IMAGE was usable in many situations, over a wide range and by teachers with very different educational philosophies. In particular it was seen as valuable by non-specialist teachers as well as by specialist art teachers with a variety of interests and approaches to art.

The teachers' evaluations also raise many other important questions about art education and computers that extend beyond the role of this particular package. These include the following:

> Under what circumstances does the use of computers make children more interested in art as distinct from more interested in computers?
>
> What new things (if any) can art teachers learn about conventional art through their own use of art packages?
>
> Art packages allow children to create artwork much more quickly. What effects does this have upon:
>
> > the quality of their conventional art;
> > their capacity to appreciate conventional artwork created by others?
>
> Should the criteria for examining children's art work be the same whether or not art packages have been used to produce it? If there should be differences what are they and how can they be justified?

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(4) BROOKES, C. Future Image?, pp.86-7

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COMPUTER-ASSISTED LEARNING RESEARCH GROUP

List of Technical Reports

These reports may be obtained from:-

Hansa Solanki, Institute of Educational Technology, The Open University,
Walton Hall, MILTON KEYNES, MK7 6AA, England.

Report No.	Title and Author
1	M.A. Bramer (1980) Using Computers in Distance Education: The first ten years of the British Open University.
3	M.A. Bramer (1980) COMAL-80 - Adding Structure to BASIC.
4	A. Jones (1980) An evaluation of the SOLO programming language: A pilot study of its use at summer school.
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7	M.W. Lewis (1980) Improving SOLO's User-Interface: An Empirical study of user behaviour and a proposal for cost-effective enhancements to SOLO.
8	A.T. Vincent (1980) Some applications of a microcomputer.
9	T. O'Shea A. Floyd (1981) Recording Children's Mathematical Behaviour.
10	A.T. Vincent (1981) Computer-assisted support for blind students: the use of a microcomputer-linked voice synthesizer.
11	P. Bacsich (1981) Viewdata-style delivery mechanisms for CAL.
12	P.J. Murphy (1981) Biological simulations in distance learning.
13	P.J. Murphy (1981) Computer simulation in Education: Genetics and Evolution.
14	I. Every (1981) Graphics and animation in teaching dialogues.
15	P.J. Murphy, E. Scanlon, E.L. Whitelegg (1981) An evaluation of simulation CAL in the Science Faculty during 1980.
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17	J. Laubsch, M. Eisenstadt (1981) Domain specific debugging aids for novice programmers.
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